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Invention: PAPER SHEET DETECTION APPARATUS

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SPECIFICATION

TITLE OF THE INVENTION

PAPER SHEET DETECTION APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2002-304619, filed October 18, 2002, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a paper sheet detection apparatus which detects the magnetic ink printed on paper sheets such as securities.

2. Description of the Related Art

One type of paper sheet detection apparatus detects a paper sheet by holding and conveying it to a detection sensor by a conveying belt, for example, or by holding and conveying a paper sheet to a detection sensor by a pair of conveying rollers.

Another type of paper sheet detection apparatus detects a paper sheet by placing a paper sheet on a conveying belt with holes and conveying it to a suction chamber. A paper sheet conveyed to a suction chamber is sucked onto a conveying belt by sucking out air through the holes in the conveying belt, and the whole non-sucked side of the sucked paper sheet is detected.

However, in the prior art, a paper sheet flaps or bends due to the vibration of a conveying belt or the fluctuation in the speed of a pair of conveying rollers, and such flapping and bending are mixed into the detection signal of a detection sensor as a noise, degrading the detection accuracy.

The present invention has been made taking notice of the above-mentioned circumstances. It is an object of the present invention to provide a paper sheet detection apparatus, which prevents flapping and bending of a paper sheet and obtain an accurate detection signal of a detection device.

BRIEF SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a paper sheet detection apparatus comprising a conveying device which conveys a paper sheet along a conveying surface; a detection device which is provided opposite to the conveying surface and detects a paper sheet conveyed by the conveying device; a guide device which is provided in at least the paper sheet take-in side of the detection device and formed with a pair of guide members disposed opposite to each other at both sides of the conveying surface; a nozzle which is provided in the opposite surface of the pair of guide members; and a gas supply device which supplies compressed gas to the pair of guide members and ejects the gas from the nozzle

between the pair of guide members.

According to a second embodiment of the present invention, there is provided a paper sheet detection apparatus comprising a conveying device which conveys a paper sheet along a conveying surface; a detection device which is provided opposite to the conveying surface and detects a paper sheet conveyed by the conveying device; a guide device which is provided in at least the paper sheet take-in side of the detection device and formed with a pair of guide members disposed opposite to each other at both side of the conveying surface; a nozzle which is provided in the opposite surface of the pair of guide members; an energizing device which elastically energizes one of the pair of guide members toward the other guide member; and a gas supply device which generates a clearance between the pair of guide members by moving one of the pair of guide members against the energizing force of the energizing device, by supplying compressed gas to the pair of guide members and ejecting the gas from the nozzle between the pair of guide members.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and

combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a top plan view of a paper detection apparatus according to a first embodiment of the present invention;

FIG. 2 is a front view showing the paper sheet detection apparatus of FIG. 1;

FIG. 3 is a side view showing the paper sheet detection apparatus of FIG. 1;

FIG. 4A is a sectional view showing the paper sheet detection apparatus of FIG. 1 taken along the line D-D;

FIG. 4B is a block diagram showing a supply mechanism which supplies compressed air to a sensor guide of the paper sheet detection apparatus of FIG. 1;

FIG. 5 is a front view showing a paper sheet detection apparatus according to a second embodiment of the present invention;

FIG. 6 is a top plan view of the paper sheet detection apparatus of FIG. 5;

FIG. 7 is a view taken along the line A-A in FIG. 5;

FIG. 8 is a sectional view showing an upper guide member of a sensor guide provided in the paper sheet detection apparatus of FIG. 5;

FIG. 9 is a bottom view showing the upper guide member of FIG. 8;

FIG. 10 is a sectional view showing a sensor guide provided in the paper sheet detection apparatus of FIG. 5;

FIG. 11 is a block diagram showing a supply mechanism which supplies compressed air to the sensor guide of FIG. 10;

FIG. 12 is a front view showing a sensor guide of a paper sheet detection apparatus according to a third embodiment of the present invention;

FIG. 13 is a top plan view of the sensor guide of FIG. 12;

FIG. 14 a front view showing a sensor guide of a paper sheet detection apparatus according to a fourth embodiment of the present invention;

FIG. 15 is a block diagram showing a supply mechanism which supplies compressed air to the sensor guide of FIG. 14;

FIG. 16 is a sectional view showing a paper sheet detection apparatus according to a fifth embodiment of the present invention;

FIG. 17 is a sectional view take along the line B-B in FIG. 16;

FIG. 18 is a top plan view showing an end shape of a sound wave guide of FIG. 16;

FIG. 19 is a block diagram showing a signal processing circuit of the paper sheet detection apparatus of FIG. 16;

FIG. 20 is a sectional view showing a paper sheet detection apparatus according to a sixth embodiment of the present invention;

FIG. 21 is a sectional view taken along the line E-E in FIG. 20;

FIG. 22 is a sectional view taken along the line F-F in FIG. 20;

FIG. 23 is a sectional view taken along the line G-G in FIG. 21;

FIG. 24 is a block diagram showing a signal processing device of the paper sheet detection apparatus of FIG. 20;

FIG. 25 is a top plan view showing a paper sheet detection apparatus according to a seventh embodiment of the present invention;

FIG. 26 is a front sectional view showing the state that a paper sheet is taken in the paper sheet detection apparatus of the same embodiment;

FIG. 27 is a front sectional view showing the state that a paper sheet passes in the paper sheet

detection apparatus of same embodiment;

FIG. 28 is a top plan view showing a first modification of a gas ejection device of the same embodiment;

FIG. 29 is a front sectional view showing the gas ejection device of FIG. 28;

FIG. 30 is a top plan view showing a second modification of the gas ejection device of the same embodiment;

FIG. 31 is a front sectional view showing the gas ejection device of FIG. 30;

FIG. 32 is a top plan view showing a third modification of the gas ejection device of the same embodiment;

FIG. 33 is a top plan view showing a third modification of the gas ejection device of FIG. 32;

FIG. 34 is a front sectional view showing a paper sheet detection apparatus according to an eighth embodiment of the present invention;

FIG. 35 is a top plan view showing a paper sheet detection apparatus according to a ninth embodiment of the present invention;

FIG. 36 is a front sectional view showing the paper sheet detection apparatus of FIG. 35;

FIG. 37 is a front sectional view showing a paper sheet detection apparatus according to a tenth embodiment of the present embodiment;

FIG. 38 is a side sectional view showing a first modification of a gas escape device of the same embodiment;

FIG. 39 is a side sectional view showing a second modification of the gas escape device of the same embodiment;

FIG. 40 is a front sectional view showing a paper sheet detection apparatus according to a eleventh embodiment of the present invention; and

FIG. 41 is a front sectional view showing a paper sheet detection apparatus according to a twelfth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be explained in detail hereinafter with reference to the embodiments shown in the attached drawings.

FIG. 1 is a top plan view showing a paper sheet detection apparatus according to a first embodiment of the present invention. FIG. 2 is a front view of the paper sheet detection apparatus. FIG. 3 is a side view of the paper sheet detection apparatus.

The detection apparatus has conveying belts 1, 2 as a conveying device, which holds both sides of a paper sheet P and conveys the paper sheet in the arrow C direction. The conveying belts 1 and 2 are laid over rollers 4a, 4b, and run. The conveying belts 1, 2 are formed with upper and lower belt parts 1a, 1b and 2a,

2b disposed opposite to each other, and hold and convey a paper sheet P by these upper and lower belt parts 1a, 1b and 2a, 2b.

A sensor guide 3 is provided as a guide device between the conveying belts 1 and 2. The sensor guide 3 is formed with upper and lower guide members 5, 6 disposed opposite to each other with a predetermined interval through the conveying surface of a paper sheet P. The upper and lower guide members 5, 6 are fixedly held by a base 11 through holders 8, 9.

In the paper sheet take-out side of the sensor guide 3, a detection sensor 12 is provided as a detection device. The detection sensor 12 is fixedly supported by a holder 9 of the lower guide member 6, for example.

Air tubes 14 and 15 are connected to the upper and lower guide members 5 and 6, respectively, to supply compressed fluid, for example, compressed air. The upper guide member 5 is supported by the upper holder 8 through a universal joint 17 and a shaft 18. The shaft 18 is movable in the length direction, but the rotation is restricted.

A coil spring 20 is inserted between the holder 8 and the universal joint 17, and the shaft 18 is inserted into the coil spring 20. The upper guide member 5 is pressed to the lower guide member 6 by the emerging force of the coil spring 20, to be parallel

along the upper surface of the lower guide member 6 by the action of the universal joint 17.

FIG. 4A is a sectional view showing the sensor guide 3 taken along the arrow line D-D in FIG. 1.

The upper and lower guide members 5 and 6 have nozzle boxes 21a and 21b, respectively. The nozzle boxes 21a and 21b are closed by lids 22a and 22b, respectively, through a packing material not shown in the drawing. The air tubes 14 and 15 are connected to the lids 22a and 22b through tube fittings 23a and 23b. Guide plates 25a and 25b are fixed to the end faces of the paper sheet take-in sides of the nozzle boxes 21a and 21b.

In the opposite surfaces of the nozzle boxes 21a and 21b, nozzles 27a and 27b are formed to eject compressed air.

FIG. 4B is a block diagram showing a gas supply device 64, which supplies the upper and lower guide members 5 and 6 with compressed air as compressed gas.

In the drawing, a reference numeral 65 denotes a compressed air source. The compressed air source 65 is connected with a manifold 68 through a pressure reducing device 66 and a solenoid valve 67 that is opened and closed by an electric signal. The manifold 68 is connected with the upper and lower guide members 5 and 6 through the air tubes 14 and 15.

Next, explanation will be given to the detection

operation of the paper sheet detection apparatus configured as described above.

First, a paper sheet P is held and conveyed by conveying belts 1 and 2, and at the same time the compressed air source 65 is operated. By the operation of the compressed air source 65, compressed air is fed out, reduced the pressure in the pressure reducing device 66, and supplied to the upper and lower guide members 5 and 6, respectively, through the manifold 68 and the air tubes 14 and 15. The supplied compressed air is ejected from the nozzles 27a and 27b, respectively.

By the compressed air ejected from the nozzles 27a and 27b, an air layer, which is determined by the pressure and flow rate of the compressed air, the atmospheric pressure, and the pressing force of the coil spring 20, is formed between the opposite surfaces of the upper and lower guide members 5 and 6, and the guide members 5 and 6 are balanced by repulsing each other.

In this state, a paper sheet P is fed between the upper and lower guide members 5, 6, and an air layer is formed between the upper and lower guide members 5, 6 and both sides of the paper sheet P, respectively. Thus, the paper sheet P is floated from the upper and lower guide members 5, 6, and guided and conveyed to the detection sensor 12 in the non-contacted state with

the both sides pressed and held by the air layers, and the information of the paper sheet is detected.

In this time, the upper guide member 5 is pressed by the coil spring 20, and the paper sheet P is kept flat without being flapped and bent.

As above described, the paper sheet P is floated from the upper and lower guide members 5, 6, and guided and conveyed in the non-contacted state with the both sides pressed and held by the air layers, and the paper sheet P is kept flat without being flapped and bent caused by the vibration of the conveying belts 1, 2.

Therefore, the detection sensor 12 can detect a signal in the state with no flapping and bending of the paper sheet P, increasing the detection accuracy.

FIG. 5 shows a paper sheet detection apparatus according to a second embodiment of the present invention. FIG. 6 is a front view of the apparatus, and FIG. 7 is a side view of the apparatus.

In these drawings, a reference numeral 31 denotes a first conveying device, which holds and conveys a paper sheet P. In the downstream side of the paper sheet conveying direction of the first conveying device 31, a first sensor guide 32 as a guide device, a detection sensor 33 as a detection device, a second sensor guide 34 as a guide device, and a second conveying device 35 are sequentially disposed along the paper sheet P conveying direction.

The first and second conveying devices 31, 35 are composed of upper conveying belts 31a, 31a, 35a, 35a disposed in parallel along the paper P with a predetermined interval, and lower conveying belts 31b, 31b, 35b, 35b provided under the upper conveying belts 31a, 31a, 35a, 35a, so as to hold and convey the paper sheet P in the arrow B direction.

The upper conveying belts 31a, 31a, 35a, 35a and lower conveying belts 31b, 31b, 35b, 35b are laid over rollers 36, 36, 37, 37. The rollers 36, 36, 37, 37 are supported by a base 41 through support shafts 38, 39.

The first and second sensor guides 32, 34 are formed with upper and lower guide members 50, 51 and 53, 54, disposed opposite to each other through a conveying surface H to convey a paper sheet P, and placed before and after the detection sensor 33.

The upper guide member 50 of the first sensor guide 32 is supported by a holder 46 through a universal joint 43, a support bar 44 and a support pin 45, and rotatable around the support pin 45. The holder 46 is fixed to the base 41. The support bar 44 is pressed by a push screw 48 and a spring member 49, pressing the upper guide member 50 to the lower guide member 51. The lower guide member 51 is fixedly provided on the base 41 through a holder 47.

The second sensor guide 34 is configured in the say way as the first sensor guide 32. The same

reference numerals are given to the same parts, and the description will be omitted.

FIG. 8 is a sectional view showing the upper and lower guide members 50, 51 and 53, 54, which constitute the first and second sensor guides 32, 34.

The upper and lower guide members 50, 51 and 53, 54 are configured in the same way, and only the upper guide member 50 will be explained as a representative. The upper guide member 50 has a nozzle box 56. The nozzle box 56 is closed by a lid 57 that is fixed through a not-shown packing member. The lid 57 is connected with an air tube 58 through a tube fitting 59. The nozzle box 56 is formed with many nozzles for ejecting compressed air, as described later.

Namely, in the opposite surface 61 of the upper and lower guide members 50, 51 and 53, 54, nozzles aj, … en are provided as a matrix of a, b, c, d, e rows and j, k, l, m, n columns, as shown in FIG. 9, and grooves ab, bc, cd, de, jk, kl, lm, mn are provided surrounding the nozzles aj, … en.

The distance between the nozzles of the j and n columns disposed in the outermost side is set larger than the width dimension of a paper sheet P.

The grooves jk, kl, lm, mn are formed in parallel along the paper sheet P conveying direction, and the grooves ab, bc, cd, de are formed in parallel along the direction orthogonal to the paper sheet P conveying

direction.

Compressed air is supplied to the nozzles aj, … en from a cavity 63 between the nozzle box 56 and the lid 57. The grooves ab, dc, cd, de are shaped like a saw tooth, so that the corners of the grooves ab, dc, cd, de do not disturb the conveyance of the paper sheet P in the arrow D direction.

The nozzles aj, … en and the grooves ab, bc, cd, de formed on the opposite surface 61 of the upper and lower guide members 50, 51, 53, 54 are provided at the opposite positions, but the nozzles aj, … en may be provided at the position shifted from the opposite positions.

FIG. 10 is a sectional view taken along the E-E line in FIG. 9, showing the positional relationship between the guide members 50 (53), 51 (54) and the paper sheet P, and the flow state of compressed air by an arrow.

FIG. 11 is a block diagram showing a gas supply device for supplying compressed air to the upper and lower guide members 50, 51 and 53, 54, which constitute the first and second sensor guides 32, 34. The gas supply device is configured in the same way as the gas supply device 64 shown in FIG. 4B, and the same reference numerals are give to the same parts.

In the drawing, a reference numeral 65 denotes a compressed air source. The compressed air source 65 is

connected with a manifold 68 through a pressure reducing device 66 and a solenoid valve 67 that is opened and closed by an electric signal. The manifold 68 is connected with the upper and lower guide members 50, 51 and 53, 54 through the air tube 58.

Next, the detecting operation of the paper sheet detection apparatus configured as above described will be explained.

First, when a paper sheet P is held and conveyed by running the conveying belt 31, the compressed air source 65 is operated. By the operation of the compressed air source 65, compressed air is supplied. The compressed air is reduced in the pressure reducing device 66, and supplied to the upper and lower guide members 50, 51 and 53, 54 through the solenoid valve 67, the manifold 68 and the air tube 58, as shown in FIG. 10.

The compressed air is ejected from each nozzles aj, … en in the opposite surfaces 61, 61 of the upper and lower guide members 50, 51 and 53, 54. By this ejection, the upper and lower guide members 50, 51 and 53, 54 repulse each other, and the ejected compressed air is exhausted to the outside of the guide members 50, 51, 53, 54 from the grooves ab, bc, cd, de around the nozzles aj, … en.

Then, the upper guide members 50, 53 are supported and raised in the direction of separating from the

lower guide members 51, 54, by the universal joint 43, the support bar 44 and the support pin 45, but stopped at the position where the air layers are balanced by the pressing force of the spring 49 and the compressed air ejecting force.

In this state, a paper sheet P is inserted between the upper and lower guide members 50 and 51, and a compressed air layer is formed between the upper and lower guide members 50, 51 and both sides of the paper sheet P. Thus, the paper sheet P is guided and conveyed to the detection sensor 33 in the floated state with both sides pressed and held by the air layers, and the information of the paper is detected.

After the information is detected, the paper sheet P is inserted between the upper and lower guide members 53 and 54 located in the downstream side, and further guided and conveyed in the floated state, as described above.

The clearance between the upper and lower guide members 50, 51 and 53, 54 and the flat part around the nozzles, and the clearance between the both sides of the paper sheet P and the flat part around the nozzles of upper and lower guide members 50, 51 and 53, 54, are 0.030 to 0.050 mm, when the compressed air pressure is set to 0.1 Mpa, the pressing force of the spring 49 is set to 0.1N, and the nozzle diameter is set to 1 mm.

Therefore, the paper sheet P is conveyed within a

space of 0.030 to 0.050 mm, and the flap and bending of the paper are negligible, and a stable detection signal is obtained in the detection sensor 33.

Further, in this embodiment, as shown in FIG. 10, in the opposite parts of the nozzles viewed from the paper sheet conveying direction in FIG. 9, the opposite surfaces of the nozzles arranged in the j-row and n-column outside of both ends of the paper sheet P has a clearance that is larger by the thickness of the paper sheet P, and the air layer flow rate becomes slower than the rate in the part where the paper sheet P exists, and the pressure rises and functions as a force to push the paper sheet P inward.

Therefore, the paper sheet P can be advanced straight between the upper and lower guide members 50, 51 and 53, 54 by inertia without meandering, even if it is not pressed by the conveying belts 31 and 35.

For more ensured conveyance of the paper sheet P within the sensor guides 32 and 34, it is recommended to set the clearance between the guide rollers 36 and 37 of the belts 31 and 35 smaller than the length of the paper conveying direction. The paper sheet P is to be held by one of the conveying belts 31 and 35, and the conveying force will not be weakened.

A reference numeral 33a in FIG. 5 denotes a dummy or a sensor fixed to the upper guide member 50 to be used as a guide of the surface opposite to the

detection sensor 33. A reference numeral 33b denotes a dummy or a sensor fixed to an upper guide member 53.

FIG. 12 shows a sensor guide 71 according to a third embodiment of the present invention.

The sensor guide 71 is formed with upper and lower guide members 72 and 73 that are disposed opposite to each at both sides of a conveying surface H to convey a paper sheet P. A paper sheet P is guided by the upper and lower guide members 72, 73, and conveyed in the arrow Q direction.

The lower guide member 73 is fixedly provided, has a plurality of nozzle holes (not shown) on the upper surface, and is connected to an air tube 74 in the lower surface.

The upper guide member 72 consists of a plurality of divided guide parts 72a. The divided guide parts 72a are arranged vertically and horizontally in the paper sheet P conveying direction and the direction orthogonal to the paper sheet P conveying direction.

Each divided guide part 72a is connected with an air tube 76 to supply compressed air. The divided guide part 72a is connected with a shaft 79 through a universal joint 78. The shaft 79 is held movable vertically by a holder 80, but the movement in the rotating direction is restricted.

A coil spring 82 is inserted in the compressed state between the holder 80 and the universal joint 78.

The shaft 79 is inserted into the coil spring 82.

The coil spring 82 presses by its restoring force the divided guide part 72a to the lower guide member 73. The divided guide part 72a has a nozzle hole (not shown) in the lower surface to eject compressed air. The nozzle hole provided in the conveying surface H of the lower guide member 73 is opposite to each divided guide part 72a.

According to this embodiment, the upper guide member 72 consists of a plurality of divided guide parts 72a arranged vertically and horizontally, and a paper sheet P can be guided within a narrower range meeting the changes in the thickness distribution of a paper sheet P, for example. This provides an advantage that flapping and bending of the paper sheet P can be suppressed more securely.

FIG. 14 shows a sensor guide 85 according to a fourth embodiment of the present invention.

The sensor guide 85 is formed with upper and lower guide members 86 and 87 that are disposed opposite to each other.

The upper guide member 86 is divided in parallel into a plurality of divided guide parts 86a - 86e only in the direction orthogonal to the paper sheet P conveying direction. These divided guide parts 86a - 86e are supported and movable in the same configuration as that shown in FIG. 12, and an air tube 88 is

connected to the upper surface.

The lower guide member 87 is configured and fixedly held in the same way as that shown in FIG. 12.

FIG. 15 is a block diagram showing a gas supply device 90 for supplying compressed air to the divided guide parts 86a - 86e of the above-mentioned upper guide member 86.

In the drawing, a reference numeral 91 denotes a compressed air source. The compressed air source 91 is connected with first and second manifolds 95, 96 through first and second pressure reducing devices 92, 93. The first and second manifolds 95, 96 are connected with the divided guide parts 86a - 86e through the air tube 88 and solenoid valves 97a - 97e.

The first pressure reducing device 92 is set to 0.1 Mpa, and the second pressure reducing device 93 is set to 0.15 Mpa, for example, to be able to supply high and low pressures to the divided guide parts 86a - 86e by switching the solenoid valves 97a - 97e by an electric signal.

According to this embodiment, it is possible to convey a paper sheet P very well on a pressure wave just like a running pressure wave, by switching the pressure of the compressed air supplied to the divided guide parts 86a - 87e to high and low at a predetermined cycle in the paper sheet P conveying direction, by switching the solenoid valves 97a - 97e.

It is also possible to obtain the conveying force by increasing and decreasing the flow rate of the compressed air, not by controlling the compressed air pressure value.

FIG. 16 is a sectional view showing a paper sheet detection apparatus according to a fifth embodiment of the present invention. FIG. 17 is a view taken along the line B-B of FIG. 16.

A paper sheet P is held by conveying belts 101, 102, and conveyed in the arrow A direction along a conveying surface 110.

A wave transmitter 103 is provided under the conveying surface, and a wave receiver 4 is provided obliquely above the conveying surface 110.

Between the wave transmitter 103 and the wave receiver 104, sound wave guides 105 and 106 are provided, and a space 107 is formed to pass the sound wave reflected from a paper sheet P.

The sound wave 103a emitted from the wave transmitter 103 irradiates obliquely a paper sheet P, reflects on the surface of the paper sheet, and becomes a sound wave 103b, or pass through the paper sheet P, scatters and becomes a sound wave 103c.

A fixed guide 108 and a movable guide 109 are oppositely disposed through the conveying surface 110. The movable guide member 109 is held by a holder 111. The holder 111 is connected to a linear bearing 115

through a joint 113 and a shaft 114, and movable in the length direction of the shaft 114.

The linear bearing 115 is secured to the fixed holder 116, and the fixed holder 116 is fixed to a base 117. A reference numeral 118 denotes a coil spring, which is loosely wound around the shaft 114. The coil spring 118 forms a press support device, which presses the movable guide member 109 to the fixed guide member 108 by the restoring force in the axial direction, between the joint 113 and the liner bearing 115.

The fixed guide member 108 is secured to a fixing holder 119. The fixing holder 119 is fixed to the base 117. A nozzle 121 is provided in the flat part of the fixed guide member 108, and a nozzle 122 is provided in the flat part of the movable guide member 109. Compressed air is supplied to the nozzles 121 and 122 from a not-shown hose through a hose joint 123.

When compressed air is ejected from the nozzles 121 and 122, an air film is formed and a certain clearance is generated between the flat parts of the fixed guide member 108 and the movable guide member 109. The air film is determined by the pressure and flow rate of the compressed air, atmospheric pressure, the areas of the opposite flat parts, the pressing force of the coil spring 118 in the flat part, and the weight of the part formed in one body with the moving guide member 109. For example, when the area of the

flat parts are about 10 cm^2, the pressing force is about 1 kgf, the compressed air is 0.1 Mpa, the weight of the movable part is about 0.2 kg, the air film thickness is 0.1 mm. A reference numeral 124 denotes guide rollers of the conveying belts 101, 102.

In the paper sheet detection apparatus configured as above described, when compressed air is ejected from the nozzles 121 and 122 of the fixed guide member 108 and the movable guide member 109, a certain clearance is made by an air film formed between the opposite surfaces. In this state, when a paper sheet P held and conveyed by the conveying belts 101 and 102 is inserted between the guide members 108 and 109, a clearance is generated by an air film formed between the fixed guide member 108 and the paper sheet P, and an air film is formed between the movable guide member 109 and the paper sheet P. Thus, the paper sheet P is guided and passed through the clearance between the paper sheet P and the guide members 108, 109 in the non-contacted state. Therefore, the paper sheet P is prevented from flapping, even if the conveying belts 101 and 102 swing.

Further, when the paper sheet P inserted between the guide members 108 and 109 passes through the ultrasonic wave transmitter 103 and the wave receiver 104, the sound wave 103a emitted from the wave transmitter 103 passes through the sound wave guide 105

and irradiates the surface of the paper sheet P. The sound wave 103a is divided into a sound wave 103b to reflect on the paper sheet P and a sound wave 103c to pass through the paper sheet P. The sound wave 103b reflected on the surface of the paper sheet P scatters from an opening 107, and a part of the penetrated sound wave 103c is transmitted through the sound wave guide 106, and detected in the wave receiver 104. In this time, if the number of paper sheet P is two or more, or the surface of the paper sheet is stuck with a transparent adhesive tape or the like, the penetrated sound wave 103c decreases and the output signal of the wave receiver 104 also decreases. Thus, the thickness and the number of the paper sheet P or a foreign matter will be detected.

FIG. 18 shows the shapes of the tips of the sound wave guides 105 and 106.

The tips of the sound wave guides 105 and 106 are squeezed to be flat, enlarged in the width direction of a paper sheet P (rectangular to the conveying direction), and narrowed to have an opening in the conveying direction. Thus, even small foreign matter can be detected with good sensitivity.

FIG. 19 is a block diagram showing a signal processing circuit.

The wave transmitter 103 is connected with an oscillator 127 through a power amplifier 128. The wave

receiver 104 is connected with an amplifier 130, a band pass filter 131, a rectifier filter 132, a comparator 133, a reference setting circuit 134, and an output terminal 135.

In the signal processing circuit, an AC voltage is supplied from the oscillator 127 to the wave transmitter 103 through the power amplifier 128. Thus, a sound wave is oscillated from the wave transmitter 103, and the sound wave passes through a paper sheet P, and is caught by the wave receiver 104. The penetrated sound wave signal caught by the wave receiver 104 is amplified by the amplifier 130, and the noise component is eliminated by the band pass filter 131, which uses the frequency of the oscillator 127 as a center frequency. After this, the penetrated sound wave signal is converted into a DC signal by the rectifier filter 132, and compared with a reference setting value in the comparator 133. When the signal voltage is lower than the compared reference value, the signal output terminal 135 outputs a signal telling that a foreign matter adheres to a paper sheet P.

According to this embodiment, it is possible to provide a foreign matter detection apparatus, which can detect a foreign matter adhered to a paper sheet P during running without contacting the paper sheet P, provide a plurality of detection units close to the width direction, and prevent flapping in the thickness

direction.

FIG. 20 is a sectional view showing a paper sheet detection apparatus according to a sixth embodiment of the present invention. FIG. 21 is a side sectional view of the apparatus.

The same reference numerals are given to the same parts as those shown in the above-mentioned fifth embodiment, and the explanation will be omitted.

In the fixed guide member 108 and the movable guide member 109, a pressure sensor 137, a hole sensor 139 and a permanent magnet 140 are provided. The hole sensor 139 is disposed opposite to the permanent magnet 140, and detects the magnetic field strength of the permanent magnet 140.

FIG. 22 is a sectional view taken along the line F-F in FIG. 20. FIG. 23 is a top plan view taken along the line G-G in FIG. 21.

A pressure measurement hole connecting to the pressure sensor 137 is bored in the fixed guide member 108 and the movable guide member 109. In the opposite surfaces of the fixed guide member 108 and the movable guide member 109, a groove 143 is provided along the paper sheet P conveying direction. The groove 143 divides the upper surface of the fixed guide member 108 into areas 108a - 108c.

The hole sensor 139 is provided at four locations in the fixed guide member 108, in FIG. 23, but the same

function can be achieved even by providing at one or two locations in the width direction of the fixed guide member 108.

In the paper sheet detection apparatus configured as above described, when compressed air is ejected from the nozzles 121 and 122 of the fixed guide member 108 and the movable guide member 109, a certain clearance is generated by an air film formed between the opposite surfaces. In this state, when a paper sheet P held and conveyed by the conveying belts 101 and 102 is inserted between the guide members 108 and 109, a clearance is generated by an air film formed between the fixed guide member 108 and the paper sheet P, and an air film is also formed between the movable guide member 109 and the paper sheet P. Thus, the paper sheet P is guided and passed between the guide members 108, 109 in the non-contacted state. Therefore, the paper sheet P is prevented from flapping, even if the conveying belts 101 and 102 swing.

When a paper sheet P with a constant thickness is inserted between the fixed guide member 108 and the movable guide member 109 in the above-mentioned operating state, if the supplied compress air pressure is constant, the thickness of the air film between the fixed guide member 108 and the paper sheet P and between the movable guide member 109 and the paper sheet P is constant, and the output signal of the

pressure sensor 137 is also constant.

When a foreign matter is stuck to a part of the surface of a paper sheet P by a transparent adhesive tape and the thickness of the paper sheet P is different, the clearance generated by the air films made between the fixed guide member 108 and the paper sheet P and between the movable guide member 109 and the paper sheet P are changed. The clearance between the pressure sensor 137 and the paper sheet P is different in the parts with and without a foreign matter.

When the clearance changes, the flow rate in the air film changes and the pressure changes as a result. In this embodiment, the position of the width direction of the foreign matter on the surface of the paper sheet P is determined by the output of the pressure sensor 137, and three pressure sensors 137 are provided in the width directions of the fixed and movable guide members 108 and 109, as shown in FIG. 22.

Further, the groove 143 is formed on the opposite surfaces of the fixed guide member 108 and the movable guide member 109, and an air flow occurs along the groove 143, and an air film is divided in the width direction along the groove 143. Therefore, the air film pressure is separated by the groove 143, and the pressure change in the width direction can be detected.

As to the output of the hole sensor 139, when a

paper sheet P is conveyed and inserted between the fixed and movable guide members 108 and 109, the clearance increases, the distance from the permanent magnet 140 increases, the magnetic field strength decreases, and the signal voltage decreases.

When there is a foreign matter on the surface of a paper sheet P, the paper thickness increases, the clearance increases, and the signal output voltage decreases furthermore.

The maximum thickness of a paper sheet P can be detected by the hole sensor 139, as described above. The maximum average thickness in the opposite surfaces of the fixed and movable guide members 108 and 109 can be obtained by detecting the thickness at two or more locations and calculating the mean value.

FIG. 24 is a schematic configuration diagram showing a signal processing device.

The pressure sensors 137, 137 are connected to a processing circuit 147 through an amplifier 146. A hole sensor 139 is connected to the processing circuit 147 through an amplifier 147. A paper sheet detection device 149 provided in the paper sheet take-in side of the guide members 108, 109 is connected to the processing circuit 147 through an amplifier 150.

The output signal of the paper sheet detector 149, and the signals from the hole sensor 139 and the pressure sensor 137 are applied to the processing

circuit 147 through the respective amplifiers 150, 146 and 147, where the signals are processed, and the paper sheet P thickness signal 152 and the surface foreign matter signal 153 are obtained.

According to this embodiment, it is possible to provide a composite detection apparatus, which can detect the thickness and a foreign matter adhered to a paper sheet P during running without contacting the paper sheet P, provide a plurality of foreign matter detection devices in the width direction of the paper sheet, and detect the thickness and the foreign matter on the paper sheet surface, without flapping the paper in the thickness direction.

FIG. 25 is a top plan view showing a paper sheet detection apparatus according to a seventh embodiment of the present invention. FIG. 26 is a front sectional view of the paper sheet detection apparatus. FIG. 27 is a front sectional view of the paper sheet detection apparatus in the state that a paper sheet is passing.

A paper sheet detection apparatus 201 has a pair of conveying belts 202 that holds both sides of a paper sheet P and conveys the paper sheet along a conveying path H. The pair of conveying belts 202 is formed with upper and lower conveying belts 202a, 202b.

In the conveying path H, a sensor 203 such as a magnetic head is provided as an inspection means. The sensor 203 detects the magnetic information of a paper

sheet P. A paper sheet P is guided by a guide device 204 so that the magnetic information is read well at the sensor 203.

The guide device 204 has sensor guides 206 and 207 as upper and lower guiding bodies, which are separated and located opposite to each other through the conveying path H. The sensor 203 is provided on the upper surface of the lower sensor guide 207.

The upper sensor guide 206 is supported by a support frame 209 movable vertically through a support rod 210. A spring 211 is wound around the support rod 210. The spring 211 elastically energizes the upper sensor guide 206 downward.

In the upper sensor guide 206, an air chamber 213 is provided, whose lower side is openable. A porous ejection device 214 is provided in the opening of the lower side of the air chamber 213. The porous ejection device 214 has the advantage of obtaining a relatively uniform static pressure in a wide range by a small compressed air pressure. The upper sensor guide 206 is connected with an air tube 215, which connects with the air chamber 213. Compressed fluid, for example, compressed air is supplied from the air tube 217 to the air chamber 213, and the compressed air is ejected from the porous ejection device 214 toward the lower sensor guide 207, as indicated by an arrow.

The ejected compressed air exists as a static

pressure air in the clearance between the opposite lower sensor guide 207, and keeps the distance d between the upper and lower sensor guides 206, 207 by being balanced with the pressing force of the spring 211. The pressing force is obtained not only by an elastic body such as a spring 211. The same function can be obtained by adjusting the weights of the members constituting the upper sensor guide 206.

When a paper sheet P is held by the pair of conveying belts 202 and conveyed to between the upper and lower guide bodies 206, 207, the paper sheet is conveyed by being pressed to the lower sensor guide 207 by the static pressure air and the pressing force of the spring 211. In this time, the upper sensor guide 206 rises so as to keep the distance d to the paper sheet P.

When compressed air of 0.5 atmospheric pressure is ejected by using two springs with the elastic force of 25 g/mm as the above-mentioned spring 211, and using an aluminum alloy (density = 2.7) of 150 mm × 70 mm × 10 mm as the upper and lower sensor guides 206, 207, the distance d between the sensor guides 206 and 207 is 0.2 mm.

The distance d between the upper and lower sensor guides 206 and 207 is at least about 1.5 time larger than the thickness of a paper sheet P. The paper sheet take-in sides of the upper and lower sensor guides 206

and 207 are formed bending and the curved surface is widely opened, so that a paper sheet P butts against and jams at the ends of the upper and lower sensor guides 206 and 207 when it is taken in.

The paper sheet P conveying force of the pair of conveying belts 2 is set larger than the friction force between the surface of the lower sensor guide 207 and the paper sheet P, to stably convey the paper sheet P. For example, the surface of the lower sensor guide 207 is coated with DLC (Diamond Like Carbon), TiN or TiC to decrease the coefficient of friction to 0.2 or lower to make the conveyance of the paper sheet P smoother.

It is generally said that a pressure of several tens g/cm^2 is required to smooth out wrinkles of paper sheets such as bills and securities.

The static pressure to press a paper sheet P between the upper and lower sensor guides 106 and 107 to the lower sensor guide 107 is equal to the force of raising the upper sensor guide against the pressing force of the spring 211 and forming the distance d to the lower sensor guide 207.

Therefore, if the static pressure formed between the upper and lower sensor guides 206 and 207 is larger than the force required to smooth out a paper sheet P by the spring 211 and by setting the compressed air pressure, a paper sheet P can be stretched to be flat while passing between the upper and lower sensor guides

206, 207, and the distance between the sensor 203 fit to the lower sensor guide 207 and the paper sheet P can be kept constant.

On the other hand, the force to press a paper sheet P to the lower sensor guide 207 becomes a frictional resistance force against the conveying force, and the frictional force can be obtained by the force obtained by multiplying the coefficient of friction of the lower sensor guide 207 by a load. By processing the surface of the lower sensor guide 207 to lower the coefficient of friction, the conveying resistance force can be made sufficiently smaller than the belt conveying force, and stable conveyance can be ensured.

Thus, a space loss can be minimized even with a paper sheet with a weak magnetic signal, and stable magnetic detection is possible.

Further, since the upper sensor guide 206 does not come in contact with a paper sheet P, the conveying resistance is small, a paper jam can be avoided and special maintenance is unnecessary.

Moreover, adhesion of paper dust and ink coming off from a paper sheet or dust caused by the wearing of a belt to the upper sensor guide 206 can be decreased, and deterioration of the inspection performance can be prevented.

FIG. 28 is a top plan view showing a first

modification of the compressed air ejection device provided in the upper sensor guide 206. FIG. 29 is a front sectional view of the device.

The ejection device is formed with an ejection port 221 in the upper sensor guide 206. According to this modification, there are advantages that an air pressure drop is small, and the costs of cleaning and parts are cheap.

FIG. 30 is a top plan view showing a second modification of the ejection device. FIG. 31 is a front sectional view of the device.

The ejection device is formed with a plurality of ejection ports 223 in the upper sensor guide 206. According to this modification, there are advantages that an air pressure drop is small, the costs of cleaning and parts are cheap, and a friction resistance during conveying a paper sheet is decreased by not applying static pressure evenly to the whole surface of a paper sheet P.

FIG. 32 is a top plan view showing a third modification of the ejection device. FIG. 33 is a front sectional view of the device.

The ejection device is formed in the upper sensor guide 206 with a groove 225 with small width along the direction orthogonal to the paper sheet conveying direction. According to this modification, the static pressure air can be distributed more widely and the

flapping of a paper sheet P can be effectively suppressed even if the paper is not hardy and flaps largely.

FIG. 34 is a front sectional view showing a paper sheet detection apparatus according to an eight embodiment of the present invention.

The same reference numerals are given to the same parts as those shown in the seventh embodiment, and the explanation will be omitted.

In this embodiment, a transparent plate 231 such as a hard glass is provided in the lower sensor guide 207. By guiding and conveying a paper sheet P along the transparent plate 231, the wrinkles and bents of the paper sheet P can be smoothed out, and a high-precision optical visual field can be obtained by eliminating the cause of a height fluctuation noise.

FIG. 35 is a top plan view showing a paper sheet detection apparatus according to a ninth embodiment of the present invention. FIG. 36 is a front sectional view of the apparatus.

The same reference numerals are given to the same parts as those shown in the seventh embodiment, and the explanation will be omitted.

In this embodiment, a pair of conveying rollers 235, comprising upper and lower rollers 235a and 235b, is disposed outside of the static pressure air area 234, so that a paper sheet P is held and conveyed by

the pair of rollers 235.

According to this embodiment, there is an advantage that static pressure air is applied to the whole surface of a paper sheet P to guide the conveyance of the paper sheet, increasing the inspection accuracy of the paper sheet P.

FIG. 37 shows a tenth embodiment of the present invention.

In this embodiment, a minute air vent 236 is provided in the lower sensor guide 207.

In this embodiment, the compressed gas ejected from the ejection device 214 in the upper sensor guide 206 presses a paper sheet P to the lower sensor guide 207, and then escapes to the outside through the air vent 236 in the lower sensor guide 207. Therefore, the remaining paper sheet P is prevented from being swollen by the compressed air flowing into the clearance between the paper sheet P and the lower sensor guide 207, and the paper sheet P inspection accuracy can be improved.

FIG. 38 shows a first modification of the air vent.

This air vent is composed of a groove 238 with small width formed in the lower sensor guide 207 along the paper sheet P conveying direction.

FIG. 39 shows a second modification of the air vent.

This air vent is composed of an uneven part 240 formed on the upper surface of the lower sensor guide 207.

Further, the air vent can also be a porous block or a small diameter hole, and can be selected depending on the quality of a paper sheet P and the type of the sensor.

FIG. 40 shows an eleventh embodiment of the present invention.

In this embodiment, a suction pump 246 is connected as a suction means to the lower sensor guide 207 through a suction pipe 245.

In this embodiment, the compressed air ejected from the upper sensor guide 206 is sucked from the lower sensor guide 207 through the suction pipe 245.

By this suction, the paper sheet P passing between the upper and lower sensor guides 206 and 207 can be tightly adhered to the lower sensor guide 207 to fit it along its shape, increasing the inspection accuracy of the sensor.

FIG. 41 shows a twelfth embodiment of the present invention.

In this embodiment, the upper sensor guide 206 is provided with a sensor 251 of the upper side and an ejection device 252, and the lower sensor guide 207 is provided with a sensor 254 of the lower side and an ejection device 253. The sensor 251 of the upper side

is opposite to the ejection device 253 of the lower side, and the sensor 254 of the lower side is opposite to the ejection device 252 of the upper side.

Compressed air is blown out from the ejection devices 252, 253 of the upper and lower sensor guides 206, 207, and static air is formed between the upper and lower sensor guides 206, 207. When a paper sheet P is conveyed between the upper and lower sensor guides 206, 207, the upper side of the paper sheet P is first pressed to the upper sensor 251 and the magnetic information is read, and then the lower side is pressed to the lower sensor 254 and the magnetic information is read.

According to this embodiment, the front and back of a paper sheet P can be inspected by passing only once between the upper and lower sensor guides 206, 207, increasing the processing efficiency.

Also, in this embodiment, it is possible to use the suction means shown in FIG. 40.

Of course, the present invention may be embodied in other specific forms without departing from its essential characteristics.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various

modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.